'Two-way signaling' possible with a single quantum particle

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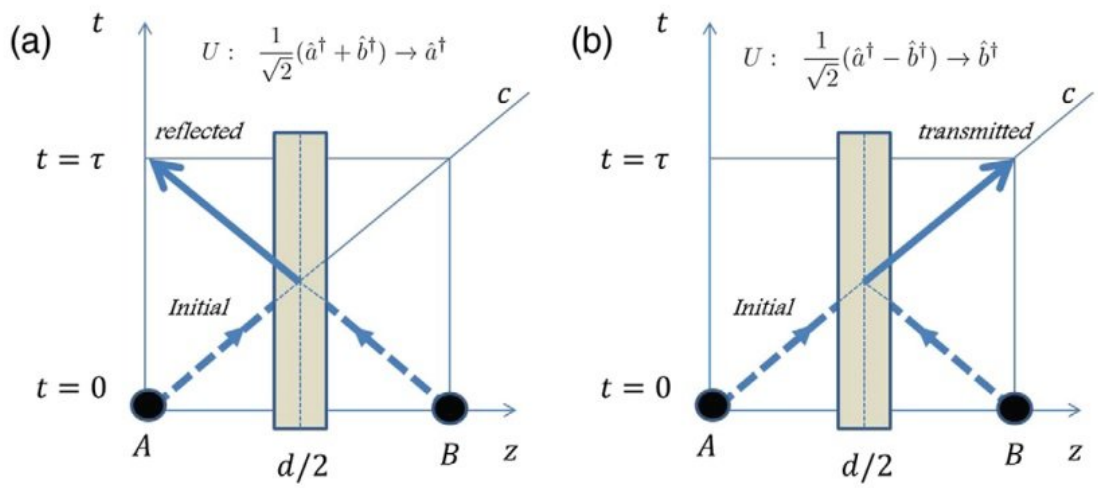

For two partners to both communicate using a single quantum particle, the particle is prepared in a superposition of two locations. When each part of the particle is sent to the partner, the particle hits a unitary device, which guides the particle in such a way that both partners get the message that has been sent to them. Credit: Del Santo and Dakić. ©2018 American Physical Society

Classically, information travels in one direction only, from sender to receiver. In a new paper, however, physicists Flavio Del Santo at the University of Vienna and Borivoje Dakić at the Austrian Academy of Sciences have shown that, in the quantum world, information can travel

in both directions simultaneously—a feature that is forbidden by the laws of classical physics.

In classical communication, such as email, text message, or phone call, a message is embedded in an information carrier, such as a particle or signal, that travels in only one direction at a time. In order to communicate in the other direction using the same information carrier, it is necessary to wait until the particle arrives at the receiver and then send the particle back to the sender. In other words, it is classically impossible to perform two-way communication by using the single exchange of a single particle.

However, this is exactly what Del Santo and Dakić theoretically show. To do this, they use a quantum particle that has been put in a superposition of two different locations. As the physicists explain, being in a quantum superposition means that the quantum particle is "simultaneously present" at each partner's location. Therefore, both partners are able to encode their messages into a single quantum particle simultaneously, a task that is essentially impossible using classical physics.

"Consider the simplest scenario, where two players, Alice and Bob, want to exchange a simple bit of information, i.e., either 0 or 1," Dakić explained to *Phys.org*. "They encode their respective bits (messages) at the same time, directly into the superposition state of a quantum particle. Once the information is encoded, the partners send their 'parts of quantum particle' towards each other.

Positioned halfway in between Alice and Bob is a unitary device, which may be experimentally implemented by, for example, a beam splitter.

"Conditioned on the messages that the particle carries, when the particle hits the unitary device, it bounces back either to Alice or Bob

deterministically," Dakić said. "More precisely, the unitary device guides the particle a 'smart way,' such that, at the end both Alice and Bob get the bit (message) that has been sent to them. For example, if the particle ends up with Alice, she would know that the Bob's bit was just opposite from her bit, and vice versa."

So in the end, both players send and receive a message—all within the same amount of time it would take to send a one-way message using a classical particle.

These theoretical results have already been verified by a new experiment using single photons, reported by Del Santo, Dakić, and their coauthors. The experimental results further strengthen the new concept by showing that the communication is secure and anonymous. In particular, the direction of communication is hidden—an eavesdropper cannot tell who is the sender and who is the receiver. Consequently, the results may lead to improvements in quantum communication that has advantages in terms of both speed and security.

More information: Flavio Del Santo and Borivoje Dakić. "Two-Way Communication with a Single Quantum Particle." *Physical Review Letters*. DOI: 10.1103/PhysRevLett.120.060503. Also at arXiv:1706.08144 [quant-ph]